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Background Aerosol Characteristics Measured with a Fluorescence Aerodynamic Particle Sizer: Sensitivity of FLAPS Performance

By:

Jim Ho and Mel Spence

March 1998

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Suffield Memorandum 1504

Background Aerosol Characteristics Measured with a Fluorescence Aerodynamic Particle Sizer: Sensitivity of FLAPS Performance

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EXECUTIVE SUMMARY

Background or ambient aerosol measurement has been an unrewarding task in that after having done the work, it is difficult to ascribe meaning to the data. However, the issues surrounding inanimate aerosol particle concentrations in air have become controversial after it was reported that a direct linkage could be made to mortality. At the same time, more concerns are raise regarding biological aerosols found downwind of farms, sewage treatment plants and other common sources of airborne microorganisms like garbage dump sites. Simple and efficient measurement of inanimate aerosol particles by light scatter techniques are well established. But a corresponding method to measure biological aerosols has not been easily achieved; most require some form of culture technique that are costly in terms of resource and time. We present here performance of an instrument based on a novel optical approach that permits real time measurement of background aerosols providing information that may suggest some inherent biological characteristics.

From observations done with flow cytometry, it was found that a single spore in liquid stream could be induced to fluoresce at 340-60 nm. In a prototype instrument, similar results were obtained when spore particles in air were excited with a ultraviolet (UV) laser. The Fluorescence Aerodynamic Particle Sizer (FLAPS) measures particle size as well as intrinsic fluorescence characteristics of individual particles in an aerosol stream. Laser light at UV wavelength is used to selectively excite aerosol material of a desired size range. The measured fluorescence signals represent intrinsic biological properties of the particles. By this method, it has been shown that inert particles like sand can be distinguished from biological particles like spores and vegetative bacteria. This instrument and its prototype have been demonstrated to effectively detect and characterise biological aerosols during joint field trial exercises in both 1995 and 1996.

Integral with the FLAPS design is an aerosol concentrator that concentrates particles in air about 400-500 times normal ambient concentration. This makes it possible to sample particles at a rate of 3 seconds and within this period, about 300-3000 total particles are processed for valid statistical counts.

To function effectively as a biological detector, the instrument compares background or ambient data to that of an unknown cloud. An ambient aerosol database from diverse localities will greatly enhance data analysis. To this end, the instrument has been use to collect data on ambient aerosols in different geographical sites, for example at DRES, Calgary, Dugway, Cornwall and Brooks, Alberta (a spot downwind from a cattle feedlot). The results show that FLAPS can distinguish between "clean" and "dirty" environments with respect to the fraction of fluorescent particles measured in a given aerosol population. By discriminating or gating fluorescent and particle size data at an optimised range (2-10 μm), it is possible to discern some environmental stability in the ambient aerosol patterns at any given locality. The ability to define stable baseline conditions greatly assists in developing alarming algorithms for detection of militarily relevant biological aerosols.

These findings also suggest FLAPS technology can be useful in public health surveillance applications where biological hazards are a concern.

ABSTRACT

From observations done with flow cytometry, it was found that a single spore in liquid stream could be induced to fluoresce at 340-60 nm. In a prototype instrument, similar results were obtained when spore particles in air were excited with a ultraviolet (UV) laser. The Fluorescence Aerodynamic Particle Sizer (FLAPS) measures particle size as well as intrinsic fluorescence characteristics of individual particles in an aerosol stream. Laser light at UV wavelength is used to selectively excite aerosol material of a desired size range. The measured fluorescence signals represent intrinsic biological properties of the particles. By this method, it has been shown that inert particles like sand can be distinguished from biological particles like spores and vegetative bacteria. This instrument and its prototype have been demonstrated to effectively detect and characterise biological aerosols during joint field trial exercises in both 1995 and 1996.

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TABLE OF CONTENTS

INTRODUCTION

Background particulate measurements of environmental air has being extensively carried out by the Environmental Protection Agency (EPA) in the US and the world (appendix 1). The data format used by this agency is expressed in total particle mass ($\mu g/m^3$) of <10 μm diameter, also known as PM_{10}. Particle mass documentation from the early 1980's to the present is available from a database accessed via EPA website with supplied display software (appendix 2). Detailed aerosol particulate sampling methodology has been clearly defined in EPA documents (appendix 3).

It took many years before health significance (mortality) in major polluted areas was linked to particle mass data. Although such cause and effect relationship was established epidemiologically (Dockery and Pope 1994) and thus, subject to much controversy, the overall thesis was confirmed by Bates (1996) after critical review of these and other works.

Unfortunately, despite existence of such voluminous data on background aerosol, none of it is of any use as indicator for biological content. We have previously used particle size distribution as a comparison to predict the presence of biological aerosol (Ho et al. 1994) in a trinational field trial. But we also cautioned that this scheme has some limitations (Ho, 1994) in that pure particle sizers cannot be expected to distinguish between a biological particle and sand of the same size. Hence we embarked on an extensive effort to discover a better way.

We have shown, by using flow cytometry techniques, that a single bacterial spore could be induced to fluoresce if excited with 320-60 nm light (Ho and Fisher, 1993). To exploit this finding, the Fluorescence Aerodynamic Particle Sizer (FLAPS) was built for measurement of biological aerosols (Hairston et al. 1997). This instrument was designed to measure particle size and fluorescence for each particle in an air stream. With this capability, analysis of the data permitted the experimenter to distinguish between biological aerosol particles and inanimate material like sand. Respirable particles (0.5-15 μm size range) are sized by the time-of-flight method, initiated by HeNe laser while biological related fluorescence is elicited with excitation by HeCd UV laser at 325 nm. Particles containing molecules that are excitable at this wavelength emit light at between 400-580 nm and this fluorescence characteristic is suggestive of biological properties inherent with the particle. There is widely available evidence demonstrating that this type of observation is related to actively metabolizing "live" organisms synthesizing intracellular fluorescent biomolecules like NADH and riboflavin (Eng et al 1989).

Naturally occurring environmental aerosols contain low biological content so a particle concentrator (350 to 1) was used to increase the signal to noise characteristics for the FLAPS. When detecting artificially generated biological aerosols, further improvement in signal to background noise could be achieved by "gating" out (a flow cytometry technique) dimly fluorescing particles as well as those <2.5 μm in diameter. Previous sampling in different locations showed that analysis of relatively clean air with gating under normal steady state background atmospheric conditions the fraction of fluorescing particles rarely exceeded 5% (Boulet et al 1996). In contrast, in the presence of a simulant biological aerosol (*Bacillus* spores, BG) a signifi-

cant increase in the number of brightly fluorescing particles could be seen, especially in the larger size range (5-10 μm).

A knowledge of the background fractional fluorescent particulate content is critical to our current alarming methodology. In this report, we examine ambient aerosol characteristics from a variety of situations with the expectation that information obtained can potentially affect ways by which alarming algorithms may be based.

METHODS AND MATERIAL

Sampling sites were selected methodically to provide an array of representative environmental conditions that reflect unknown background situations relevant to alarming software development. Dugway and Suffield were obvious choices, being the only significant centers for biological field trials globally. The Calgary site was an interesting example of a city environment with the added advantage of unusual activities taking place at the time of the trials. It was open house day at Canadian Forces Base Calgary so there was vehicular traffic plus people traffic among trees and fields. More interestingly, aerosol sampling was done down wind of a shooting range where parents brought their children to fire military weapons using blank ammo. The cattle feedlot site at Brooks, Alberta was expected to represent high biological content in the air. There was an added bonus on the day of sampling; earth moving activity in the vicinity stirred up significantly high aerosol content. The Cornwall cite represented what we expected to be naturally "clean" air off the west coast of UK with influence from the Atlantic ocean.

The optical and electronic components of FLAPS1 have been described in detail (Hairston et al 1997) and will be briefly summarized here. Ambient or atmospheric aerosol particles are concentrated by a virtual impactor at about 350:1 providing an enriched 1 liter per minute air stream to the detector inlet nozzle. Single particles are individually sized by the time-of-flight method and then excited by a UV laser. A continuous wave HeCd laser is used in FLAPS1 while a pulsed frequency triple laser (1.06 μm diode laser source) provides 340-350 nm light in FLAPS2. In each case, the fluorescent signal is measured by a conventional photo multiplier tube (PMT). The electronics of both were calibrated and tuned to provide similar outputs. In this report, no distinction is made between data from either instrument.

Using standard microbiological methods, live bacteria were assessed by plating on nutrient agar and incubation overnight at 37° C. Number counts were converted to colony forming units per liter aerosol using 1000 l/min as the high volume sampler flow rate.

Statistical data analysis was done with SigmaStat version 2 for Windows (Jandel Scientific, San Rafael, CA 94912-7005). Data sets that failed normal distribution tests were analysed by a non-parametric method (Mann Whitney Rank Sum Test). Data smoothing (Savitzky Golay method) was done with Tablecurve version 4 from the same vendor.

RESULTS AND DISCUSSIONS

Custom software was used to manipulate data streams to display size (X axiz), fluorescence (Y axis) and concentration information (Z axis) as 3 dimensional plots (Figure 1, left). In this example, a 3 second sample of DRES ambient aerosol was presented in this format, showing the total particles measured. This was a typical sample representative of a "clean" day when about 200-500 particles were measured per 3 second sampling period. Of these numbers, a small fraction showed some fluorescent properties and these are represented as discrete histogram blocks of individuals arrayed as increasing brightness in corresponding size ranges. Although this sample was taken in the middle of a Canadian winter at -17° C, the aerosol characteristics were similar to those of any "clean" day during other times of the year.

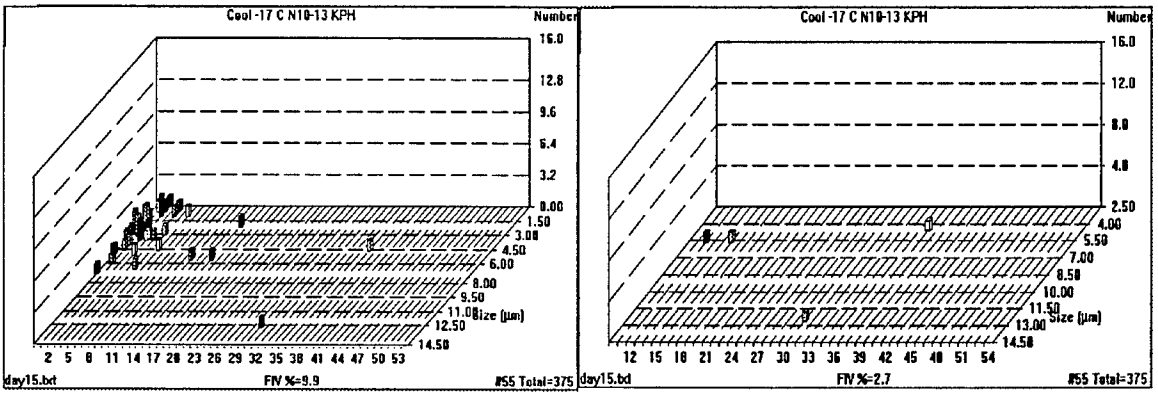

Figure 1. Normal ambient aerosol measured by FLAPS raw data (left) and gated (right). Raw particle numbers were sorted according to size distribution and fluorescent brightness. The particle items were presented cumulatively in number concentration for a 3 second sample. Gating involved not plotting particle sizes <2.5 µm and brightness channels < 10.

A concept of enhancing the data display called gating was adapted from flow cytometry. This involved removing "noise" or unwanted data electronically or in this case via software, resulting in better signal to background noise characteristics. In Figure 1 (right), the dim fluorescent channels (<10) were eliminated as well as data from particle sizes <2.5 µm. This results in a relatively noise free plot and at the same time, a prorated fractional fluorescent value was also shown (2.7). By this technique, it has been observed that "clean" air rarely registered >5% fluorescent particle content, even with ambient samples recorded in Calgary (Figure 2) where relatively high levels of human and vegetative contributions might be expected to raise fluorescent content in air.

In figure 2, particle numbers appeared to change dramatically with time, apparently influenced by the various activities related to Armed Forces Day open house. There were many visitors walking around as well as heavy vehicle traffic within the area. The detector was situated down wind of a rifle firing range where parents brought their children to try out automatic weapons shooting blanks.

Throughout all these activities, the fluorescent fraction did not register above the arbitrary ambient gated threshold of 5% and changes in particle concentration did not affect fractional fluorescent content.

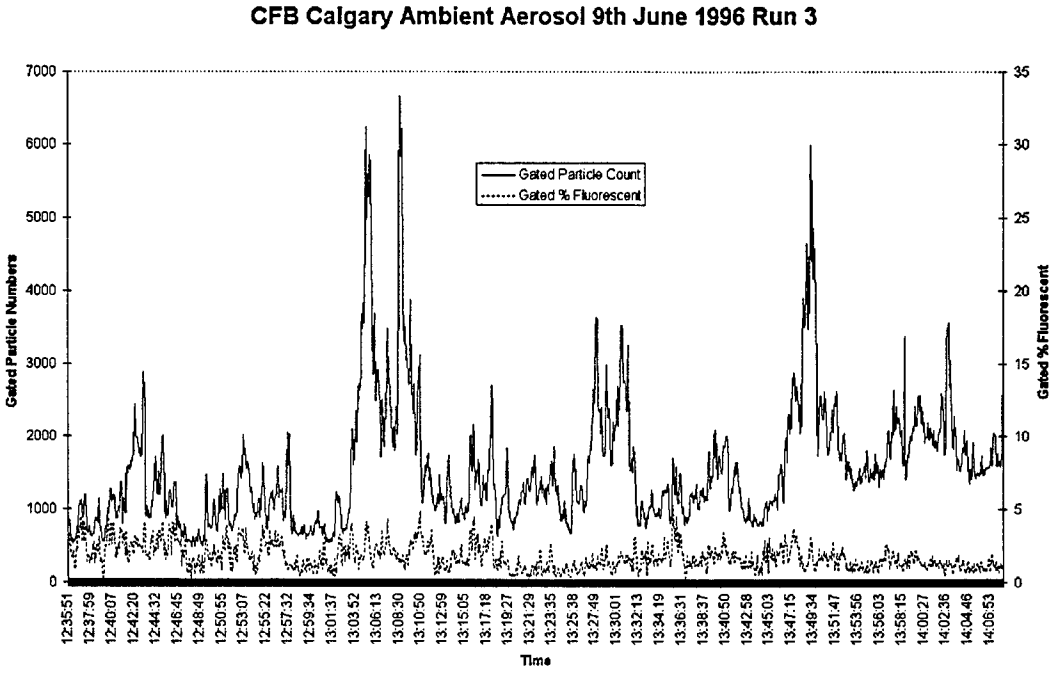

Figure 2. Calgary ambient aerosol on a summer day in June 1996. Example shown was rune 3 of a series of data sets taken over a day. Gated particle numbers are those >2.5 μm summed for the 3 second sampling period.

Part of the reason to measure ambient aerosols is the opportunity to discover "unusual" situations where fluorescent signals may be abnormal. It was a surprise to note that on a very cold day when the temperature dropped to -31° C at DRES, significant number of bright fluorescent particles were measured (Figure 3). Indeed, the gated fractional fluorescent value went up to above 21.3% (Figures 3 and 4), an unusually high observation for this region.

Figure 4 shows gated % fluorescent vs time on a very cold day. The high fractional fluorescent content registered by the FLAPS referred to in figure 3 corresponds to the peak of the curve at about 11:56:00 (Figure 4). Note that the ambient fractional fluorescent value during the whole experiment was well above the arbitrary 5% proposed earlier to represent "clean" air. Also worthy of note is that the total particle numbers sampled each time was not unusually high, confirming our observation with respect to particle concentration and fluorescence.

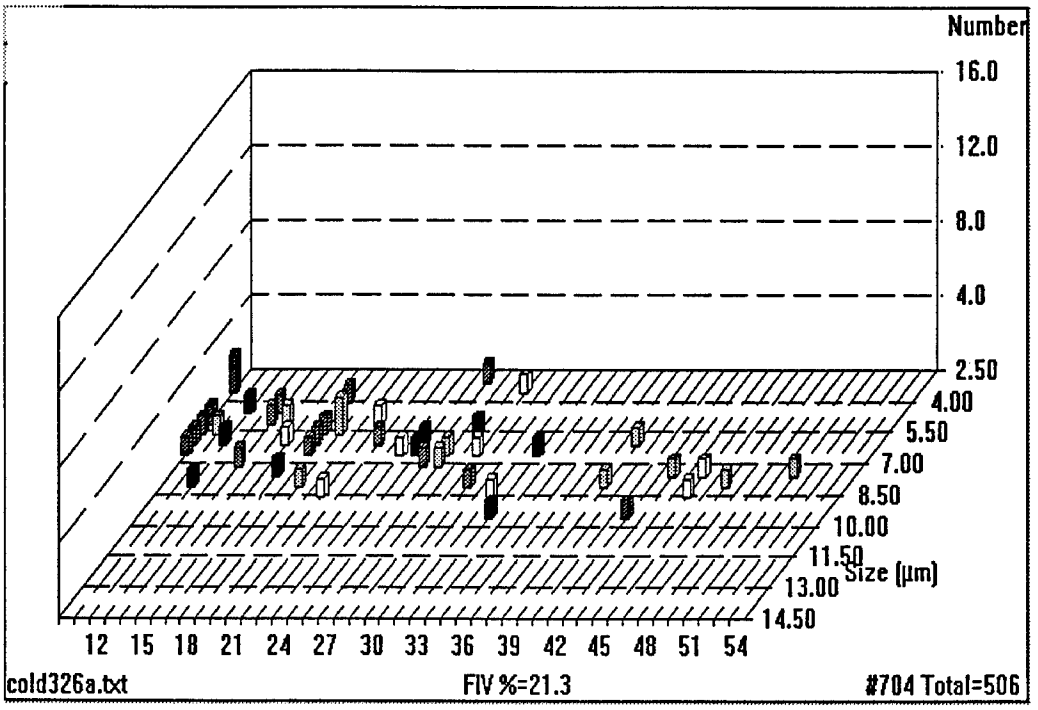

Figure 3. Ambient aerosol on a cold day containing high fraction of fluorescent content.

It is possible that the extreme temperature conditions must have played a role in causing the appearance of relative high fluorescent content. Indeed, on another similarly cold day, comparable observations were seen. Extreme coldness could have made it possible for smaller particles to coagulate into larger ones. Indeed, on reexamining the size distribution information, it was observed that there was an unusually low fluorescent contribution from the <2.5 µm population suggesting that the small particles somehow formed larger aggregates at low temperature.

One immediate practical reason for studying ambient aerosol characteristics was to determine how the information could be used to design alarming algorithms. Figure 5 shows an example of time based plot from a clean day when the fractional fluorescent content was well below the 5% threshold. Fluctuations and variance behaviors in the ambient data points required non-parametric statistical methods for analysis. The appropriate averaging term computed via this is "median" and for the background portion of this experiment the value of 0.6 was obtained. In contrast, the median during aerosol passage (hit) between approximately 5:24:00 and 5:30:00 was 3. As tested by Mann Whitney Rank Sum Test (P=<0.001), there was a significant difference between the background and hit aerosol populations when expressed as fractional fluorescent count. Using a simple moving average computer program to compare new incoming FLAPS data to existing background data, it was possible to establish alarming conditions reasonably well as shown in figure 5.

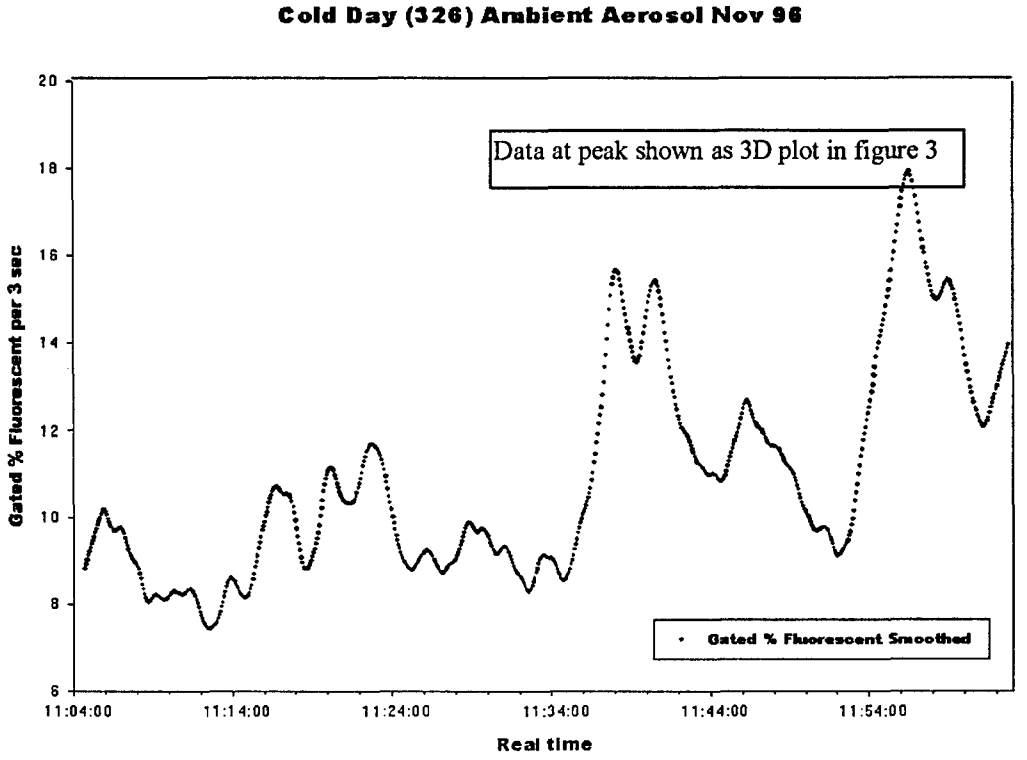

Figure 4. Time study of ambient aerosol on a cold day when high fractional fluorescent content was encountered.

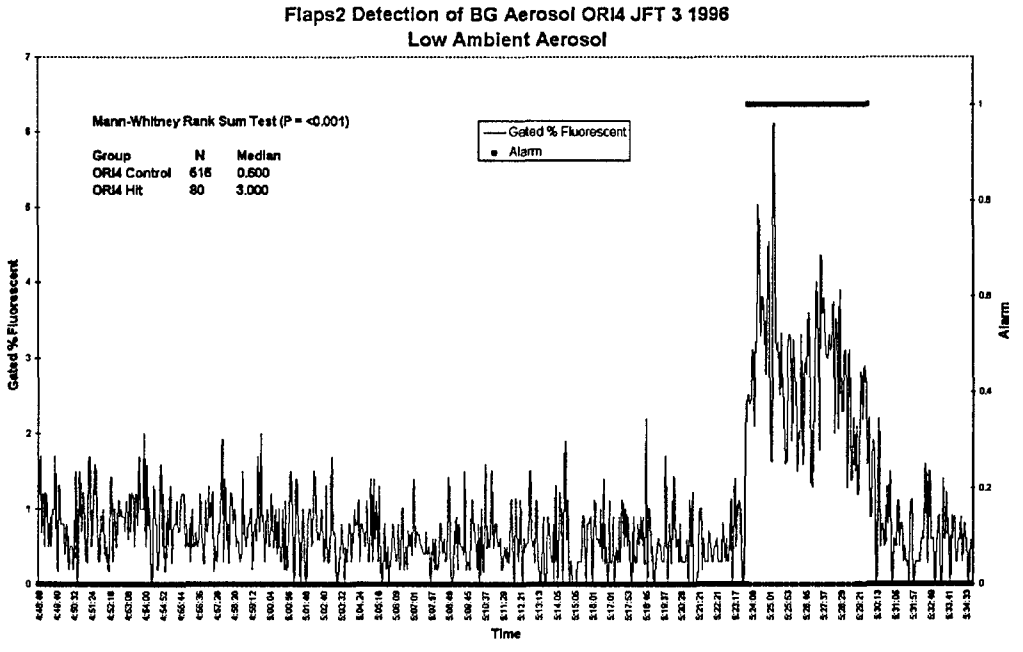

Figure 5. Detection of biological aerosol under low fluorescent background condition measured during JFT3 at Dugway in September 1996.

It is of interest to note that the real time alarming algorithm using simple moving average techniques could derive fairly good results. Not shown here but employing data from previous field trials, our alarming method produced results that alarmed at correct times referenced to live biological data supplied by the trial sponsors. In this example we have also illustrated that post trial statistical analysis confirmed significant difference between background and aerosol hit measurements. We now need to know how high background aerosol conditions could affect this alarming methodology.

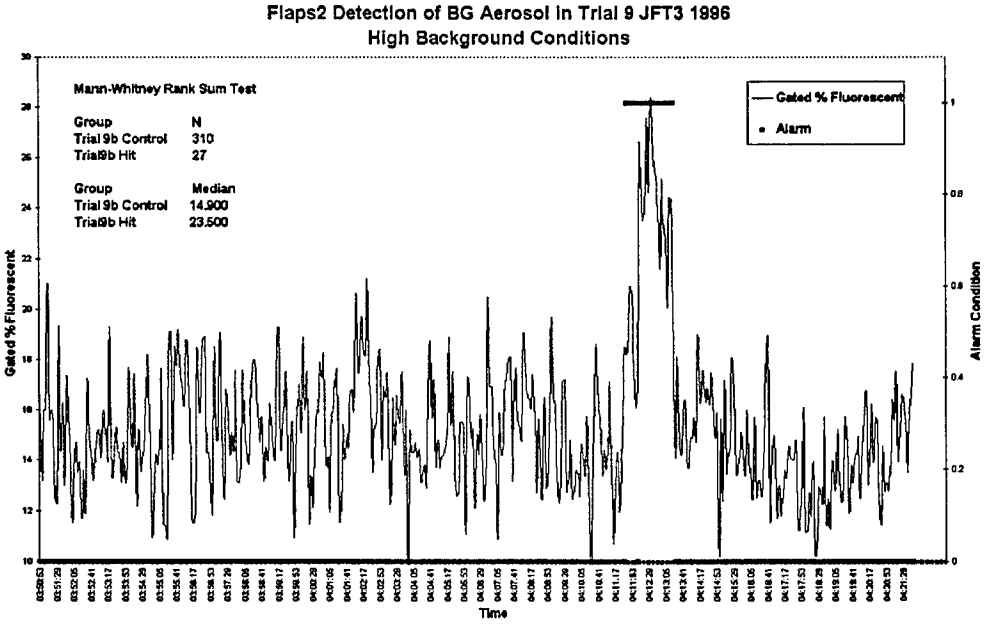

Figure 6. Detection of biological aerosol under high fluorescent background condition.

During some trials in JFT3 (Dugway 1996), the fractional fluorescent content was found to be unusually high, far above the 5% threshold observed previously. However, in the example in figure 6 where the median was almost 15, it was evident that the passage of an aerosol cloud could still be detected (4:11:50-4:13:30). During this brief hit lasting only a few minutes, the alarm system functioned well as confirmed by post trial statistical analysis.

It was difficult to explain the background condition just described. But during another trial (Figure 7) it was likely that the stormy weather preceding it could have brought high ambient fractional fluorescent conditions giving a median of more that 18. Storm related increases in particle numbers have been recorded in Edgewood, Maryland, (Wick 1996) but fluorescence characteristics were not measured. However, in this case, the passage of biological aerosol cloud could still be detected by the alarming system. During its brief appearance, a statistically significant median of 28.5 was calculated.

These examples suggest that the data treatment and alarming methodology may provide some immunity to absolute ambient noise levels. We have previously

shown that this scheme as employed by the FLAPS system was also insensitive to gross fluctuations in total particles numbers (3). Other environmental factors that need be examined to test for system reliability would be wind speed and direction. For instance, it could be envisioned that high wind speeds cause unpredictable ambient aerosol conditions, enough to distort proper data treatment. Figure 8 shows a FLAPS measurement of ambient fractional fluorescent material on a high wind day, averaging to 40 km/h. It can be seen that the overall value detected was well below the 5% threshold. Also shown here is the gated particle counts related to the gated % fluorescent derivative. These particle numbers fall within our previously defined "clean" category. The results suggest that high winds did not necessarily cause high background noise in the measured parameters although it should be mentioned that this observation might be specific for DRES. Conversely, we have measured high background particle concentrations on days with relatively low wind speed. Similarly, we have not been able to attribute wind directions to changes in background observations. Indeed, high winds or directional changes did not appear to have any appreciable effects on FLAPS performance thus suggesting that the data treatment scheme has great potentials in resisting ambient "noise".

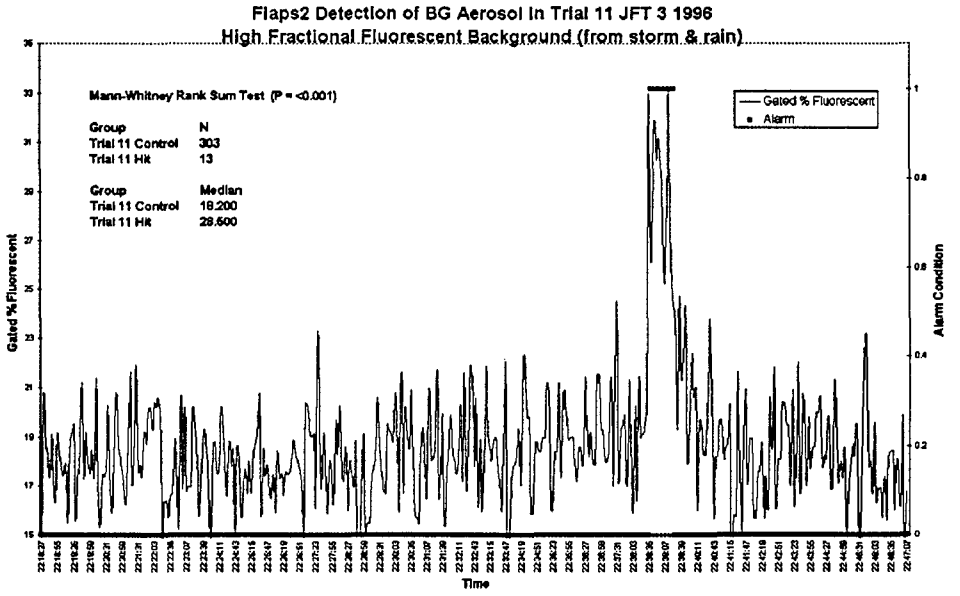

Figure 7. Detection of biological aerosol under high fluorescent background condition related to severe a storm front.

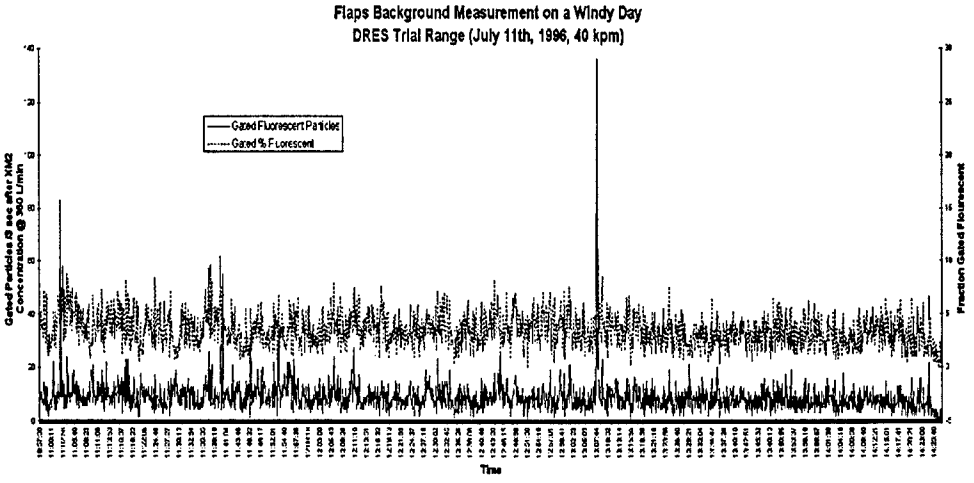

Figure 8. Measurement of ambient aerosol under high wind conditions.

From the rationale used to develop FLAPS technology (1 & 4), there was reason to speculate that background fluorescent particles as measured by the instrument were related to live biological organisms. To test this, a high volume sampler was used to collect aerosol particles in liquid at 5 minute intervals. The samples were subjected to conventional microbiological assessment. In figure 9, FLAPS fluorescence data was compared temporally with live bacteria numbers. The ambient samples were taken down wind of a cattle feedlot. There was much construction vehicle activity in the surrounding area so the aerosol particles generated may have come from various sources. In figure 9, except for the 11:31:00 sample, most other live data histograms correlated well with fluorescent data. It is tempting to suggest that FLAPS was capable of detecting the presence of live organisms at the concentrations shown here but more work must be done to confirm this.

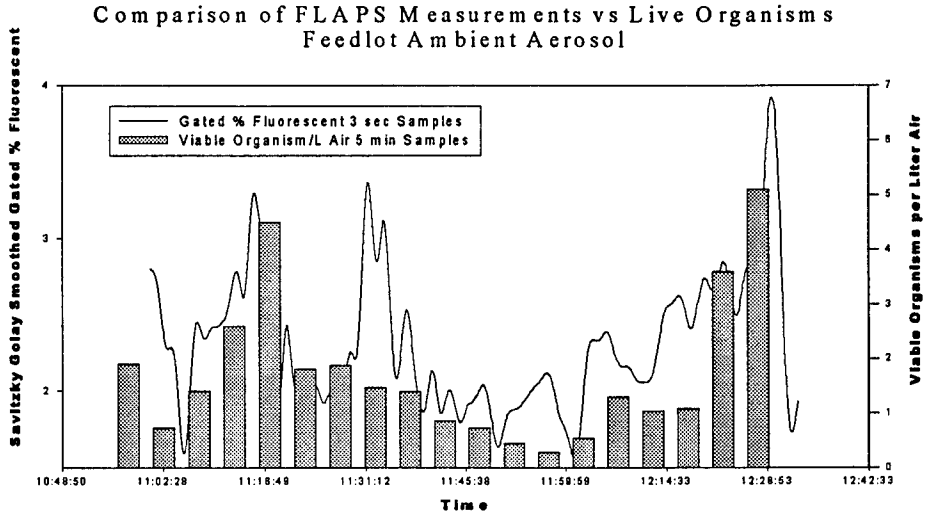

Figure 9. Evidence demonstrating relationship between ambient fluorescent signals and live organisms.

In contrast to what has been shown from the feedlot ambient aerosol where biological material was expected, we wanted to sample at a location where the background air was predicted to be "clean". For this, FLAPS was located at the southeastern end of the Cornwall peninsular near Lizard Point where the wind was high and coming mostly from the direction of the ocean. This expectation was verified as demonstrated in figure 10.

Because of low to non-measurable fluorescent content in the air, the ungated plot shows all the brightness channels including channel zero which represents non-fluorescent particles. Particle numbers in channel 1 represent noise from the optical system, previously verified by calibrating the instrument with non-fluorescent particles like NaCl or latex beads. In other analysis, anything below channels 3-5 have been considered as having insignificant fluorescent measurements. Thus in this experiment, it can be concluded that little to no fluorescent material was found in the background. As a confidence calibration check, a spore aerosol introduced about 3 m upwind of the detector produced suitable signals (data not shown) indicating that the instrument was indeed functioning correctly.

The other observation of interest is that the ambient air at this location contained very high particulate counts, roughly ten to twenty times what have been encountered in other locations. It is anticipated that such high numbers may potentially cause problems with purely light scatter instruments with respect to detection and alarming efficiency. However, based on what has been demonstrate and discussed, such ambient "noise" levels are not expected to present difficulties for the FLAPS functional schema.

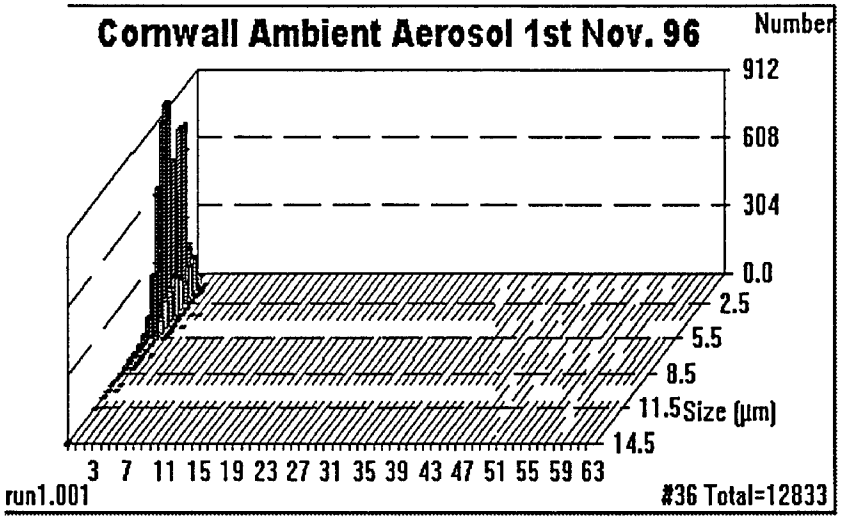

Figure 10. TTCP TP-10 Sampling Project Cornwall Nov. 1996. Clean ambient air characteristics.

CONCLUSIONS

We have shown that FLAPS in combination with an aerosol concentrator could provide background particle and fluorescence data amenable to non-parameteric statistical analysis. To achieve this at 3 second sampling intervals required a minimum concentration ratio of 350:1 and this gave sufficient measurable particle numbers to define conditions for "clean" environments.

By using an accepted flow cytometry technique of gating, a single term fractional expression in percentage of a population represented fluorescent information that appeared to be immune to external or most environmental influences.

More importantly, we have also demonstrated that under a variety of background situations, a simple alarming algorithm appeared to function independent of background fluorescent levels. There was a situation where the fluctuations in fluorescent levels could potentially disrupt the alarming system but this occurred at -31° C, an environment incompatible with BW scenarios.

It is of course tempting to be critical of our location choices as they appeared to be, in some instances, sites of convenience. In most instances, that was true but it must be emphasized that any attempt at comprehensive background aerosol measurement eventually becomes limited by cost and time. So we have clearly defined the scope of our effort and spelt out precisely our aims. After having done the work, we are confident to report that the alarming algorithm methodology is robust enough to survive without false alarm errors given the representative locations. Moreover, with the encouraging results presented here, we planned to continue similar work in diverse localities when time and budget permit.

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APPENDIX 1

AQS Data - USA Max Value Report - PM10

This report lists the 10 (out of 100) highest concentrations of Particulate Matter smaller than 10 micrometers (PM10) reported by U.S. monitors during 1996. The #Exc column tells how many days of the year had a concentration exceeding the EPA national ambient air quality standard for PM10 (Particulate < 10 micrometers Annual arithmetic mean 50 $\mu g/m^3$; 24-hour Average 150 $\mu g/m^3$).

The AIRS database is updated weekly to reflect revisions, additions, and deletions by the state and local organizations who own and submit the data. The small sample of AQS data presented here is refreshed monthly. The data below were extracted from the AIRS database on August 01, 1997. They represent the best information available to EPA from state agencies on that date. However, some values may be incorrect and reporting may be incomplete. Please contact the pertinent state agency to report errors.

St	County	1stMax	2ndMax	#Obs	#Exc	Type	Monitor Address
1	MO Howell Co	1712	1321	55%	101	Other	WEST PLAINS CHARCOAL NORTH
2	IN Porter Co	609	208	90%	2	SLAMS	HWY 12 WASTE LAGOON
3	CA Inyo Co	491	221	50%	19	SLAMS	190 CERRO GORDO ROAD, KEELER
4	PA Philadelphia C	454	356	84%	81	SLAMS	CASTOR AND CARBON STS ON PGW
5	CA Imperial Co	441	440	94%	48	Other	CALEXICO - EAST
6	NV Clark Co	386	279	78%	10	SLAMS	1137 NORTH BOULDER HIGHWAY
7	MO Howell Co	363	223	28%	16	Other	WEST PLAINS CHARCOAL NORTH
8	CA Imperial Co	359	110	92%	6	SLAMS	150 9TH ST., EL CENTRO
9	NV Clark Co	339	328	70%	7	SLAMS	210 EAST FLAMINGO ROAD
10	NV Clark Co	300	270	80%	6	SLAMS	4001 EAST SAHARA AVENUE

APPENDIX 2

US EPA Office of Air Quality Planning and Standards

AIRS Executive for Windows is the newest member of the AIRS Executive family, released in January 1997. It is personal computer software and database that contains a select subset of data extracted from the AIRS database. Its user-friendly Windows interface guides you to air pollution information on U.S. ambient air quality and pollutant emissions from stationary sources. Many different maps, charts, and reports are available.

AIRS Executive USA is a personal computer database that contains a select subset of data extracted from the AIRS database. Its user-friendly menus guide you to air pollution information on U.S. ambient air quality and pollutant emissions from stationary sources. AIRS Executive operates entirely in graphics mode and displays a variety of maps, charts, and reports. Note: This DOS version of AIRS Executive will be discontinued as of 9/30/97. The same U.S. data is available in a Windows version, AIRS Executive for Windows.

AIRS Executive International is a special version of AIRS Executive that contains information about ambient air pollution in nations that voluntarily provide data to the GEMS/AIR Programme sponsored by the United Nations World Health Organization. Nearly 50 nations are participants. The GEMS/AIR data is stored in the AIRS database, just like EPA data for the United States. AIRS Executive International is an easy way to view summaries of GEMS/AIR pollution monitoring data.

All versions of AIRS Executive are provided absolutely free of charge by EPA. You may use it any way you wish, as long as you do not sell the software or data.

Who Is It for?

AIRS Executive is designed to provide quick access to a subset of air pollution information. Managers, supervisors, and non-technical staff will find it especially helpful in obtaining easy-to-read summaries of air pollution data. Take a laptop to a meeting, for example, and air pollution data is readily at your fingertips. Non-technical users also will find AIRS Executive to be an invaluable resource in obtaining air pollution information regarding their communities.

What Does It Do?

AIRS Executive is a menu-driven program, in which options appear in the form of icons. From any menu, you can use your mouse or keyboard to select an option. The main menu choices represent the types of information available in AIRS Executive:

* The Information section contains general information about AIRS and each of its five subsystems, as well as information about AIRS Executive.
* The Data section is the heart of program. It has reports and charts that summarize air pollution values reported by monitoring sites, and emissions estimates from major sources of pollution. (The International version does not include pollution sources.) A report or chart displays data for a particular geographic area, pollutant, and year that you choose. Several types of reports and charts of air pollution data are available. In addition, you can view the tables of codes used in AIRS, such as pollutant codes and geographic abbreviations.
* The Maps section provides a sampling of maps from the AIRS Graphics subsystem. For example, there are maps showing the locations of air pollution monitoring sites.
* The Contacts section lists names and phone numbers of people to contact for further assistance on each AIRS subsystem.

What Do I Need to Use AIRS Executive?

DOS versions of AIRS Executive can be loaded in minutes on any PC with 15 megabytes of hard disk space, and 400K of RAM (500K to view certain maps). The Windows version of AIRS Executive runs on any PC with Windows 3.1 or 95 and 30 megabytes of hard disk space. The Windows version is intended for stand-alone installation. Other verions of AIRS Executive can be installed on a LAN and shared by many people.

Where Does the Data in AIRS Executive Come From?

The data used in AIRS Executive to produce reports and charts are extracted monthly from the AIRS database on EPA's mainframe computer. Maps in AIRS Executive are produced by AIRS Graphics, also on EPA's mainframe. AIRS Executive includes maps that show monitor and plant locations in the USA for each of the criteria pollutants. AIRS Executive International includes maps that show locations of GEMS/AIR monitoring sites at world, continent, and national scales. In addition, there are samples of several other types of maps and charts available to those who have direct access to AIRS Graphics on EPA's mainframe computer. AIRS Executive updates are published by the 10th day of each month.

What if I Need More Detailed Data?

The AIRS mainframe database contains the most comprehensive air pollution data in the world. The mainframe is housed at EPA's National Computer Center in Research Triangle Park, North Carolina, USA. Any organization or individual with direct access to the EPA computer system can use AIRS to retrieve non-confidential air pollution data.

AIRS Executive is not intended to replace the AIRS mainframe. Unlike the mainframe, AIRS Executive does not allow you to manipulate data or to custom-format reports, nor does it contain the extensive air pollution data found in AIRS. Rather, AIRS Executive presents the most significant measures of air pollution in a format that is easy to use and understand. These key data values provide a great deal of information. But if you need specialized or very detailed air pollution data, the mainframe AIRS database is the place to get it. The procedures for requesting AIRS data are described elsewhere.

How Do I Get AIRS Executive Software?

Get it right here!
Choose a version -- USA or international data -- and use your Web browser to download it:

* AIRS Executive for Windows (USA data)
* AIRS Executive USA
* AIRS Executive International

Get it from the TTN!
AIRS Executive software also is available from the Technology Transfer Network. For many years the TTN was an electronic bulletin board system accessible only by modem. In 1996, EPA added Internet access methods, and now you also can connect to the TTN through the Web, FTP, and Telnet. More detailed information about the TTN is available elsewhere.

[*] To get AIRS Executive software from the TTN using your Web browser, go to the AIRS Graphics/AIRS Executive Software/Manuals section of the AIRS Bulletin Board. Click on the name of each file to download it.

[*] To get AIRS Executive software via FTP:
- Establish a connection to the Internet and start your FTP program
- Connect to Internet address ttnftp.rtpnc.epa.gov
- Change to directory e-drive/airs/graph/aexec (USA version) or e-drive/airs/graph/aeint (International version)
- Download all files in the directory

[*] To get AIRS Executive software via modem:
- Set your communications software for 8 data bits, 1 stop bit, no parity (8-1-N)
- call 919-541-5742
- login to the TTN
- choose gateway, option T
- choose AIRS BBS, option J
- choose AIRS Executive Software, option X
- choose AIRS Executive or AIRS Executive International, option 1 or 2
- enter the D command to download each file

Need More Information?

The AIRS Contacts page tells how to get in touch with EPA staff who can answer your questions about AIRS Executive. Or, you can use the Comments link below to send e-mail.

http://www.epa.gov/airs/aexec.html April 2, 1997

APPENDIX 3

PARTICULATE MATTER from The Code of Federal Regulations 40(CFR)

Air pollutants called particulate matter include dust, dirt, soot, smoke and liquid droplets directly emitted into the air by sources such as factories, power plants, cars, construction activity, fires and natural windblown dust. Particles formed in the atmosphere by condensation or the transformation of emitted gases such as SO2 and VOCs are also considered particulate matter.

Based on studies of human populations exposed to high concentrations of particles (sometimes in the presence of SO2) and laboratory studies of animals and humans, there are major effects of concern for human health. These include effects on breathing and respiratory symptoms, aggravation of existing respiratory and cardiovascular disease, alterations in the body's defense systems against foreign materials, damage to lung tissue, carcinogenesis and premature death. The major subgroups of the population that appear to be most sensitive to the effects of particulate matter include individuals with chronic obstructive pulmonary or cardiovascular disease or
influenza, asthmatics, the elderly and children. Particulate matter also soils and damages materials, and is a major cause of visibility impairment in the United States.

Annual and 24-hour National Ambient Air Quality Standards (NAAQS) for particulate matter were first set in 1971. Total suspended particulate (TSP) was the first indicator used to represent suspended particles in the ambient air. Since July 1, 1987, however, EPA has used the indicator PM-10, which includes only those particles with aerodynamic diameter smaller than 10 micrometers. These smaller particles are likely responsible for most of the adverse health effects of particulate matter because of their ability to reach the thoracic or lower regions of the respiratory tract.

The PM-10 annual and 24-hour standards specify an expected annual arithmetic mean not to exceed 50 ug/m3 and an expected number of 24-hour concentrations greater than 150 ug/m3 per year not to exceed one. Samples are collected at a frequency of every day, every other day or every sixth day depending on the conditions in a particular monitoring area.

Title 40, Part 50 of the Code of the Federal Regulations lists the ambient air quality standard for particulate matter.

Sec. 50.6 National primary and secondary ambient air quality standards for particulate matter.

(a) The level of the national primary and secondary 24-hour ambient air quality standards for particulate matter is 150 micrograms per cubic meter (ug/m3), 24-hour average concentration. The standards are attained when the expected number of days per calendar year with a 24-hour average concentration above 150 ug/m3, as determined in accordance with appendix K to this part, is equal to or less than one.

(b) The level of the national primary and secondary annual standards for particulate matter is 50 micrograms per cubic meter (ug/m3), annual arithmetic mean. The standards are attained when the expected annual arithmetic mean concentration, as determined in accordance with appendix K to this part, is less than or equal to 50 ug/m3.

(c) For the purpose of determining attainment of the primary and secondary standards, particulate matter shall be measured in the ambient air as PM10 (particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers) by:

(1) A reference method based on appendix J and designated in accordance with part 53 of this chapter, or

(2) An equivalent method designated in accordance with part 53 of this chapter.

[52 FR 24663, July 1, 1987]

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Background Aerosol Characteristics Measured with a Fluorescence Aerodynamic Particle Sizer: Sensitivity of FLAPS Performance

4. AUTHORS (Last name, first name, middle initial. If military, show rank, e.g. Doe, Maj. John E.)

Ho, J. and Spence, M.R.

5. DATE OF PUBLICATION (month and year of publication of document)

March 1998

6a. NO. OF PAGES (total containing information. Include Annexes, Appendices, etc.)

11

6b. NO. OF REFS (total cited in document)

5

6. DESCRIPTIVE NOTES (the category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

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9a. PROJECT OR GRANT NO. (if appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant)

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10a. ORIGINATOR'S DOCUMENT NUMBER (the official document number by which the document is identified by the originating activity. This number must be unique to this document.)

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From observations done with flow cytometry, it was found that a single spore in liquid stream could be induced to fluoresce at 340-60 nm. In a prototype instrument, similar results were obtained when spore particles in air were excited with a CW UV laser. The current instrument, Fluorescence Aerodynamic Particle Sizer (second generation FLAPS2) measures particle size as well as intrinsic fluorescence characteristics of individual particles in an aerosol stream. Laser light at UV wavelength is used to preferentially excite aerosol material of a selected size range. The measured fluorescence signals represent intrinsic biological properties of the particles. By this method, it has been shown that inert particles like sand can be distinguished from biological particles like spores and vegetative bacteria. This instrument and its prototype have been demonstrated to effectively detect and characterise biological aerosols during joint field trial exercises in both 1995 and 1996.

Integral with the FLAPS design is an aerosol concentrator that provides about 400-500 times normal ambient concentration. This makes it possible to sample at a rate of 3 seconds and within this period, about 300-3000 total particles are processed.

To function effectively as a biological detector, the instrument compares background or ambient data to that of an unknown cloud. An ambient aerosol database from diverse localities will greatly enhance data analysis. To this end, the instrument has been use to collect data on ambient aerosols in different geographical sites, for example at DRES, Calgary, Dugway, Cornwall and a spot downwind from a cattle feedlot. The results show that FLAPS can distinguish between "clean" and "dirty" environments with respect to the fraction of fluorescent particles measured in a given aerosol population. By discriminating or gating fluorescent and particle size data at a strategic range, it is possible to discern some environmental stability in the ambient aerosol patterns at any given locality. The ability to define stable baseline conditions greatly assists in developing alarming algorithms.

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Bacteria, Ambient, Background, Aerosol, Detection, Fluorescence Aerodynamic Particle Sizer